

Vascular plants recorded from Christmas Island

by C. R. Long

Sixty-three species of vascular plants are recorded for Christmas Island. One known hybrid is noted. Collections of vascular plants from Christmas Island have been made by the following: Dr. Streets, 1873; Mr. Dall, 1873; H. F. Bergman, August 1924; G. P. Wilder, December 1924; H. St. John and F. R. Fosberg, October 1934; H. St. John and C. M. Cooke, Jr., October 1934; F. R. Fosberg, August 1936; F. R. Fosberg and A. M. Metraux, August 1936; F. R. Fosberg and E. M. Metroux, August 1936; M. D. Gallagher (RAF Natural History Society), October 1958; D. C. Hamilton, April 1962; and C. R. Long, June and November 1964, June 1965. The specimens, as designated below, are deposited in the United States National Museum (USNM), the B. P. Bishop Museum (BISH) and the University of Hawaii (UH).

Pandanaceae

Pandanus tectorius Sol.

Bergman 32 (BISH). Apparently all of the Pandanus sp. and var. have been introduced to the island. Rougier (1914) mentions the introduction of a taxon which he called P. odoratissimus by the Lewers Company who worked the island for copra. Since the importation of Gilbertese labor species or cultivars from the Gilbert Islands may be expected. The plants observed in the village of London in 1965 were used for plaiting and food according to three informants.

Gramineae

Cenchrus echinatus L.

Hamilton 2 (BISH). Probably introduced after 1936 as Fosberg (1943) does not list this species. This species was observed in 1964 and 1965 in the village of London and near the abandoned military installations on the north side of the island.

Digitaria pacifica Stapf.

Bergman 7 (BISH), Fosberg 13218, 13231, 13262 (BISH); St. John and Fosberg 17492 (BISH); Long 1850, 1903, 3424, 3470 (UH). Mentioned by Rougier (1914) as "Paragrass". This species has naturalized over the north and southeast portions of the island forming a grassland type vegetation with Lepturus. Probably of nineteenth century introduction.

Eleusine indica (L.) Gaertn.

Hamilton 17 (BISH); Long 3407 (UH). Probably introduced during the second world war or later as it is not present in earlier collections or mentioned by Fosberg (1943). Naturalized along the northwest portion but not abundant.

Eragrostis tenella (Link.) Beauv.

Bergman 15 (BISH); Fosberg 13229 (BISH); Long 1896, 2798 (UH). First collected in 1924 this weedy grass was probably introduced in the late nineteenth or early twentieth century with the activities attending the development of the copra plantations. Common in London village and other disturbed sites.

Eragrostis whitneyi Fosberg

Bergman 14 (BISH); St. John and Fosbert 17489 (BISH); Fosberg 13195, 13230, 13266 (BISH); Long 1853, 1892, 2745, 2755, 2764, 3417, 3420, 3472 (UH). A small grass native to the Line, Phoenix, Hawaiian Leeward and the Gilbert Islands. This species covers large areas on the interior of the island especially low areas near the lagoon edge, lagoon islets and saline pools. It was observed as a pioneer on recently deposited sand on Motu Tabu and Motu Upua and on the interior of both of these islets.

Lepturus repens (Forst.) R. Br.

Bergman 1 (BISH); St. John and Cooke 17481 (BISH); Fosberg 13196; 13206 (BISH); Hamilton 11 (BISH); Long 1851, 1851a, 1852, 1884, 1894, 1900, 1901, 1908, 1915, 2766, 2789, 2794, 3421, 3431, 3471, 3488 (UH). This bunchgrass is found over large areas from sand beaches to the upper slopes above the large lagoons. Often found with stolons in well watered sites. An important stabilizer of the sandy soils found on low atolls.

Cyperaceae

Cyperus rotundus L.

Fosberg 12172; Fosberg and Metraux 13282 (BISH); Long 3486 (UH). First collected in 1934, and one clump was found in the coral gravel of the village in 1965. This introduced sedge is not abundant.

Fimbristylis cymosa R. Br.

Hamilton 1 (BISH) as F. atollensis St. John; Long 1897, 2775, 3448, 3475, 3477 (UH). First collected in 1962 and now common in London village and around disturbed sites on the north side of the atoll. It appears to be spreading to adjacent Cocos groves.

Palmae

Cocos nucifera L.

Long 3484, 3485 (UH). Small groves of Cocos were reported by Cook (1784) in 1777. The planting of additional nuts began in 1777 and continues to the present. The number of trees has doubled in this century. The original groves were undoubtedly planted by early Polynesian visitors (Emory, 1934). A number of small trees to 3 m. high of a dwarf variety were found in the courtyard of the BOQ near London village. Mr. Cook informed me that these had been brought in from Fiji. This short tree has long pendant fronds and small fruits.

Casuarinaceae

Casuarina equisetifolia L.

Long 3410 (UH). Several trees planted at London and Paris villages. One tree at Paris was 3 m. high. No evidence of reproduction was seen. The trees are protected by metal fencing.

Araceae

Cyrtosperma chamissoniana (Schott.) Merr.

This cultivated aroid was observed planted in tin drums which were placed in a depression with .3 m. of water in the bottom and the entire pit fenced with sheet roofing as crab guards. The plants did not appear vigorous. Mr. Cook explained that the Gilbertese women request this type of food during pregnancies.

Liliaceae

Allium fistulosum L.

This cultivated vegetable was observed growing in the garden of the District Commissioner.

Amaryllidaceae

Crinum asiaticum L.

This plant was observed in the village of London in 1965.

Ficus tinctoria Forst. f.

Long 3474 (UH). Cultivated on the northwest side of the island near the babai (taro) pits. Introduced from the Gilbert Islands where it is commonly cultivated for the small fruits (Luomala, 1953).

Nyctaginaceae

Boerhavia repens L.

Bergman 10a (BISH) as B. diffusa L., 9, 10b, 11 as B. tetrandra; Wilder s.n. (BISH) as B. tetrandra; St. John and Cooke 17483 as B. diffusa var. tetrandra, 17482, 17484 as B. diffusa; St. John and Fosberg 17495 as B. diffusa var. pubescens; Gallagher D. (Bish) as B. diffusa, Hamilton 9 (BISH); Long 1857, 1891, 1909, 1912, 1913, 2743, 2746, 2747, 2758, 2759, 2773, 2774, 2777, 2778, 2790, 2795, 3399, 2400, 3433, 3443, 3444, 3450, 3491 (UH). Common over the entire island in sandy soils. A common pioneer in newly planted Cocos groves and other disturbed sites. This species is highly variable and the specimens from Christmas Island are tentatively grouped under the epithet B. repens (see Chock, and Hamilton 1962).

Mirabilis jalapa L.

Long 3436, 3446 (UH). An ornamental planted near the abandoned barracks and native houses in London village.

Pisonia grandis R. Br.

Bergman 8 (BISH); St. John and Cooke 17479 (BISH); Fosberg 13193 (BISH); Long 1910a,b, 3473 (UH). Trees reported from the "northern part of the island" from a "shallow depression on coral plain" (herbarium label) - see Christophersen (1927). These were noted to be 6-7 m. high. No evidence of these was found in 1964-65. Pisonia was collected from Motu Tabu in 1934 and 1936 recorded from "coral gravels" and "sand flats, small tree 5 m. tall" (herbarium labels). The tree referred to in these collections is still present and about the same height. Several smaller trees were also observed in 1964. The larger tree bore abundant fruits and had dropped a considerable percentage of foliage during the dry season. There was heavy litter beneath the trees. The other collection (Long 3473) is from the wells on the northern portion and according to Mr. Cook these were planted. The Pisonia on Motu Tabu is of particular interest since no evidence of a phosphatic hardpan was observed under these young trees.

Aizoaceae

Sesuvium portulacastrum var. griseum Deg. and Fosb.

Dall s.n. (USNM); Bergman 13 (BISH); St. John and Fosberg 17493 (BISH); Gallagher K. (BISH); Hamilton 12 (BISH); Long 1894, 1895, 2765, 3418, 3434, 3489 (UH). This variety is found in the Phoenix and Line Islands. It is common on low saline soils usually over a damp coralline hardpan bordering the lagoons and lagoon islets of Christmas Island. Often found as the only plant on the low islets of the lagoon or with Eragrostis whitneyi. On some more elevated islets of the lagoon this species appears to be followed in drier sites by Heliotropium. Dead mats of Sesuvium with young Heliotropium plants among the dead stems were observed on several occasions in 1965.

Portulacaceae

Portulaca lutea Sol.

Bergman 4 (BISH); Wilder s.n. (BISH); Fosberg 13188 (BISH); Fosberg and Metraux 13220, 13223, 13236 (BISH); Hamilton 14 (BISH); Long 1895, 1906, 2740, 2761, 2769, 2792, 2796, 3404, 3432 (UH). Common on sandy soils and over hardpans throughout the island. Found under Cocos groves and on recently exposed hardpans of the central area.

Portulaca oleracea L.

Long 3435, 3469 (UH). Found near gravel pits of Observation Point.

Portulaca sp.

Cooke 17478 (BISH) as P. Johnii; Fosberg 13269 (BISH) as P. fosbergii; Hamilton 16 (BISH) as P. fosbergii; Long 2760, 3490 (UH). These collections are grouped together until data from the most recently collected specimens can be compared with the older collections.

Lauraceae

Cassytha filiformis L.

Bergman 34 (BISH); Fosberg 13235 (BISH); Fosberg and Metraux 13213 (BISH); Gallagher M (BISH); Hamilton 7 (BISH); Long 1888, 1914, 2746, 2793, 3430 (UH). This parasite is common on Scaevola and Heliotropium.

Hernandiaceae

Hernandia ovigera L.

Long 3490 (UH). This 2 m. high tree was planted in Poland village. One tree of this species, but smaller, was observed in London village.

Cruciferae

Lepidium bidentatum Mont.

Christophersen 48 (BISH); Long 3427 (UH). Found in 1924 by Christophersen "among Scaevola on SE peninsula" (herbarium label). This species was recollected in 1965 from the same area growing in thin sandy soil over hardpan near the edge of a lagoon with Heliotropium and Scaevola.

Rosaceae

Rosa sp.

Two types of cultivated rose bushes were observed in 1965. One of these was growing in the garden of the District Commissioner, the other was cultivated outside a small building between the wharf and the BOQ. This latter plant was in excellent condition and blooming during our visit.

Leguminosae

Erythrina variegata var orientalis (L.) Merr.

Mentioned by Rougier (1914 as having been planted earlier by the Lewers Company. Three trees to 2.5 m. high were observed in London village in 1965.

Leucaena leucocephala (Lam.) de Wit

Observed growing along the main road in the village of London. Also found on Washington Island.

Phaesolus lathyroides L.

Fosberg 13272 (BISH). An introduced species not seen in 1965.

Rutaceae

Citrus aurantiifolia (Christ.) Swingle

One tree to 2 m. was observed cultivated by the residence of the District Commissioner, Mr. Cook.

Zygophyllaceae

Tribulus cistoides L.

Bergman 23 (BISH); Gallagher G. (BISH); Hamilton 13 (BISH); Long 1856, 1886, 1899, 1911, 2729 (UH). Abundant in disturbed areas especially on the north side at roadsides and in newly planted Cocos groves.

Simaroubaceae

Suriana maritima L.

Streets s.n. (USNM); Bergman 5 (BISH); Wilder 6 (BISH); St. John and Cooke 17480 (BISH); Fosberg 13192, 13264, (BISH); Fosberg and Metraux 13217 (BISH); Gallagher C (BISH); Hamilton 18 (BISH) Long 1847, 1889, 1890, 1904, 1916, 2744, 2761, 3426 (UH). This species was mistaken by Rougier (1914) for Pemphis acidula. This shrub is common on the lagoon filled central area usually forming a rim type vegetation around the lagoon or a pioneer on the hardpan left when a shallow area drains dry. When found around a lagoon Scaevola is usually above the band of Suriana; on dry hardpans the Suriana tends to mix with Scaevola shrubs; and, over flooded hardpan as observed on the northwest part of the island the Suriana forms a thick solid stand with Scaevola forming a rim on higher, dry land. In some of the dry central portions of the island Suriana forms an association with Hedyotis. These are always found together growing on a dry hardpan with shallow soil.

Euphorbiaceae

Acalypha wilkesiana Muell. -Arg.

This ornamental shrub was observed in the village of London in 1965. A colorful native of Fiji, this species is used as hedging in the Gilbert Islands where the colorful leaves are prized for decoration (Luomala, 1953). This plant has also been introduced to Washington and Fanning Islands.

Euphorbia hirta L.

Bergman 19 (BISH), Fosberg and Metraux 13248 (BISH), Long 3408 (UH). Common weed probably introduced in the late nineteenth or early twentieth century. Confined to the villages of London and Poland in disturbed sites.

Phyllanthus amarus Schum. and Thon.

Bergman 16 (BISH) as P. niruri; Fosberg 13276 (BISH) as P. niruri. This species was not observed in 1965.

Guttiferae

Calophyllum inophyllum L.

Long 3437 (UH). Several trees to 2 m. were planted in front of the abandoned BOQ in London village.

Malvaceae

Abutilon indicum Sw.

Fosberg and Metraux 13215 (BISH). This species was not found in 1965.

Verbenaceae

Clerodendrum inerme (L.) Gaertn.

Long 3487 (UH). An introduced ornamental shrub was found in the villages of London and Paris. This species was probably brought by the

Gilbertese from their native islands where it has many uses (Luomala, 1953).

Lantana camera L.

This plant was observed growing as an ornamental in the village of London in 1965. It did not appear to be spreading from local plantings.

Solanaceae

Lycopersicon esculentum Mill.

Long 3447 (UH). This species is found in London village and naturalized under the Cocos groves on the northwest side. It was reported as cultivated near the airport (Chock and Hamilton, 1962). One of only a few introductions which have naturalized to any extent.

Rubiaceae

Hedyotis romanzoffiensis (C. and S.) Fosberg

Bergman 12 (BISH), St. John 17491 (BISH), Fosberg 13194, 13234, 13284 (BISH), Long 1918, 3468 (UH). First noted by Rougier (1914). Found in saline soils over hardpan at lagoon edges. Common in the central portion of the island with Suriana, Portulaca lutea and Scaevola.

Morinda citrifolia L.

This small tree was observed under cultivation in the village of London in 1965. It appears to require much attention and was not observed self sowing as on some of the formerly inhabited and dry Phoenix Islands.

Goodeniaceae

Scaevola taccada (Gaertn.) Roxb.

Dall s.n. (USNM), Bergman 20 (BISH), St. John and Fosberg 17496 (BISH), Fosberg and Metraux 13216 (BISH), Fosberg 13233 (BISH), Gallagher B. (BISH), Hamilton 10 (BISH), Long 1846, 1885, 2742, 2754, 2757, 2763, 2770, 2791, 3406, 3428, 3441, 3451 (UH). This species forms a dense thicket over large areas of the island. Much of the Tornefortia - Scaevola association on the north side has been cleared and planted to Cocos.

Compositae

Lactuca sativa L.

A variety of this garden plant was observed cultivated in gardens in the village of London in 1965.

Pluchea indica (L.) Less.

Hamilton 8 (BISH), Long 2787, 3449 (UH). An introduced ornamental found near the abandoned barracks on the north side.

Pluchea odorata (L.) Cass.

Gallagher J. (BISH), Hamilton 4 (BISH), Long 1907, 1908, 2753, 2786 (UH). This introduced ornamental was probably introduced during the second world war. It appears to be spreading on the north side and on the north end of the southwest peninsula where it forms thickets.

Pluchea indica X odorata

Long 2788, 3429, 3436 (UH). This natural hybrid is persisting and spreading on the north side near the airport. Natural hybrids were also found on Palmyra Island.

Verbesina encelioides (Cav.) Benth. and Hook.

Long 3439 (UH). Ornamental planting persisting in front of the BOQ near London. This species was also observed growing as an ornamental near houses in the village. There is no evidence that this species is spreading from the village area.

Vernonia cinerea Less.

Bergman 22 (BISH), Long 3492 (UH). This species was introduced before 1924. Common in London village and sparingly along the road leading north from the village.

Hibiscus tiliaceus L.

Bergman 17 (BISH); Fosberg 13267 (BISH); Hamilton 15 (BISH); Long 3442 (UH). A small tree, introduced before 1924 but not included in Christophersen's paper of 1927. This plant was observed in the village and planted near the abandoned barracks on the northwest side.

Hibiscus rosa-sinensis L. var.

Long 3398, 3442 (UH). An introduced ornamental shrub common in the village of London. This large flowered shrub is highly prized by the Gilbertese for ornament.

Sida Fallax Walp.

Dall s.n. (USNM) as S. Dielli; Bergman 18 (BISH) as S. rhombifolia; Fosberg 13191, 13283 (BISH); Fosberg and Metraux 13210 (BISH); Fosberg and Metraux 13225. Gallagher E (BISH); Hamilton 6 (BISH); Long 1858, 1887, 1919, 2756, 2772, 2776, 3403, 3425 (UH). This native shrub is common on the up-land areas in sandy soil with Lepturus and Portulaca lutea.

Caricaceae

Carica papaya L.

Long 3437 (UH). Several plants were observed near the airport and in the village of London. Several informants told me that this species is difficult to grow and seldom bears fruits.

Cucurbitaceae

Cucumis sativus L.

Long 3440 (UH). Formerly cultivated near the BOQ by London village.

Cucurbita pepo L.

This species was observed in cultivation in the village of London in 1965.

Lecythidaceae

Barringtonia asiatica (L.) Kurz.

Several trees of this species were observed growing in the village of London in 1965.

Araliaceae

Polyscias guilfoyei (Cogn. and March.) Bailey

This species was observed used as hedges in the village of London in 1965.

Apocynaceae

Plumeria rubra L.

This species, a shrub to 1.8 m. high was observed in London village in 1965.

Convolvulaceae

Cuscuta sp.

Long 3419 (UH). This specimen is probably referable to C. arvensis L. This thin stemmed parasitic vine was found on an islet of a lagoon which parallels Carver's Way. It was parasitizing Heliotropium. This is the only known site of occurrence on Christmas Island.

Ipomoea batatas (L.) Lam.

Observed cultivated in sand and humus mounds in the village of London in 1965.

Boraginaceae

Cordia subcordata Lam.

One tree to 1.9 m. was observed growing in the garden of the District Commissioner's residence.

Heliotropium anomalum var. mediale Johnston

Bergman 2 (BISH), Wilder 7 (BISH), St. John and Fosberg 17486, 17487, 17488, 17494, (BISH) Fosberg and Metraux 13209, (BISH) Fosberg 13190, 13232, 13273, 13274 (BISH), Gallagher H 1 and 2 (BISH), Hamilton 3 (BISH), Long 1851, 1854, 1858, 1893, 1905, 2741, 2762, 3401, 3422, 3476 (UH). Common sand species found over much of the island. An important stabilizer of soil.

Tournefortia argentea L. f.

Bergman 6 (BISH), St. John and Cooke 17477 (BISH), Fosberg 13189 (BISH), Fosberg and Metraux 13219 (BISH), Gallagher A (BISH), Hamilton 5 (BISH), Long 1896, 2771, 3402 (UH). A small tree forming scrub cover in back of beaches and over large portions of the central lagoon area.

Vegetation History

The early accounts of the vegetation of Christmas Island are meager. Apparently the Cocos were present on the island at the time of discovery in 1777. (Cook, 1784). A few cocoa-nut trees were seen in two or three places; but, in general, the land had a very barren appearance. "Cook investigated the lagoon and landed on what may have been the present day Motu Upua: "We walked, or rather waded, through the water, to an island; where finding nothing but a few birds, -- I left it, and proceeded to the land that bounds the sea to the North-West, --. I found this land to be even more barren than the island I had been upon; --". In commenting on two lost seamen Cook remarks on the southeast portion: "--nor was there any thing to obstruct their view; for the country was a flat, with a few shrubs scattered upon it; --". Cook also mentions planting melon seeds, yams and coconuts on Cook Island. Further mention is made of a few coconut trees "the number of which did not exceed thirty", other trees (possibly Tournefortia or Scaevola), Sida, "a sort of purslane" (probably Portulaca lutea), "a mesembryanthemum" (undoubtedly Sesuvium) and two species of grasses (Lepturus and Eragrostis?).

Since evidence of Polynesian visits and possibly short term habitation of the island has been gathered (Emory, 1934) it is possible to assume that even the earliest Cocos groves were planted by man. The island was visited by Bennett (1840) who gives the following: "The land is extremely low, and composed of sand with only a few bushes and small trees." -On the western parts there are some scattering groups of cocoanut trees; the whole number of trees may be about 2,000. -On the west point, or rather on the point which forms the southern entrance to the lagoon, there is a group of these trees having the names of several whale ships carved upon them. -I wish to state, that during my dentention, I had cocoanuts brought up from the west and planted on the south side, due south of the spot where we were wrecked." He goes on to say that these had sprouted and were on the east side and hoped that they would be a warning to ships making the SE end of the island.

The extension of the Cocos groves proceeded under the direction of Fr. Emmanuel Rougier whose account (1914) gives the first modern account of both the Cocos operations and the native vegetation: Due to the accuracy of the account we reproduce it here:

"The flora of Christmas Island is very poor owing to its position. Only the long floating seeds could obtain a footing or chance to grow on the Island and they had to be sand plants. Probably centuries passed before any seed was washed on shore, except a few grass seeds that might have been imported by birds, not as food (all birds/ living there on fish), but in their feathers. This accounts for the long and high hills all around the Islands, fully 20 to 30 feet higher than Fanning. Today the grass and shrub have taken possession of the soil and hills have ceased to increase or to move about. The grasses are: 1^o A hgi h tough grass, also found on Fanning, and no good for cattle or sheep (probably Digitaria); 2^o Paragrass, tender and green, most precious grass for cattle (Lepturus); it grows on sand hills where the sand is coarse, especially the east end of Christmas. Both creep on the soil. Another grass is called by me Honey Grass, as the flower smells of honey, a very fragrant odor;

the flowers are small white things with yellow centre, there are millions all over Christmas (Heliotropium anomalum-a perennial hut-photograph also confirms this designation). It is the most common grass, about 12 inches high, and keeps the soil wonderfully moist and cool. These, with another low dark-green creeper, not common at all, are the only grasses of Christmas (Boerhavia).

Shrubs. - The most common is the Kurima or Ogea not known in Fiji, plenty at Fanning (Sida). Cattle is very fond of it. It grows 6 to 8 feet high and very thick, then dies out and others come out, and their rotting, of course enriching the soil. When exposed to the sea breeze they branch out and creep on the soil; when inland they grow straight up; that are always a good sign of fertile soil. The Gia or Ironwood, not found at Fanning, grows only on the beach (Suriana). Its roots are in brackish water, no Cocoanuts would do where the Gia grows. Its name is Pemphis acidula. Its height is not more than five feet. (note - Pemphis acidula has never been collected from Christmas Island.) The next shrub is the Scaevola Koenigii or Nashu, a thick growing one, and where they grow you should not hesitate to plant cocoanuts. Many trees planted by Levers were saved by the shade of the Nashu. It grows about 10 to 15 feet high, more like a vine than a tree. The only tree growing there is the Taunu or Roro ni bebe _____, known as the Tournefortia argentea. It grows umbrella shape. _____ It perishes when flooded by fresh or rain water. There is always a certain amount of phosphate where it grows.

Four trees of drala Erythrina indica have been planted by Levers and do very well. Also a few screw pines Pandanus odoratissimus, have been planted, and our natives were chewing their fruit for the 18 days were there.

This with a small shrub 2 feet high, dark green, and red cherries (Hedyotis)(very few of them), are the only plants on the Island, and all have long floating seeds, with two or sometimes three-floaters."

Illustrations which accompany this good description confirm the presence of the following: Cocos, Sida fallax, Heliotropium, Pandanus sp., Scaevola taccada, Tournefortia argentea, Lepturus repens, and Suriana maritima. The west third of Motu Manu the present day Moto Upua is shown with Cocos, Tournefortia and Suriana the major species found there today.

The major changes in the vegetation of Christmas Island have occurred as a result of the extension of the Cocos plantations. Christophersen (1927) estimates the numbers at 300,000 while in 1965 Mr. Cook estimated minimum of 630,000 trees. The trunks of some Cocos in the more mesic sites have an orange lichen (probably Anthracotheicum sp.) scattered over the trunk. The upland area mentioned in Christophersen's work is largely eradicated in 1965 due to clearing for military installations and the continued enlargement of the Cocos plantation. Suriana maritima appears to have been largely removed from the beaches about London but is still found N of the village on both sides of the Cocos groves. The Lepturus - Tribulus association mentioned by Christophersen appears to have spread especially the Tribulus,

which is now found commonly around the island and on the interior. The spread of this spiny-fruited herb probably was greatly facilitated by the building of roads and other installations at the time of the bomb testing. No pure stands of Boerhavia were observed scattered plants in beach sand excepted. No areas were observed where Boerhavia was crowding and killing other species.

The vegetation of Cooks Island remains the same except for the absence of Hedyotis (the Kadua of Christophersen's paper). Christophersen mentions Pisonia on the north side but there are no extant collections from this locale. All later collections are from Motu Tabu or the planted tree near the wells.

At the present large portions of the land area of Christmas Island is covered with a Cocos forest planted by man. Large areas of the natural vegetation are being removed for the enlargement of these plantations. Due to the nature of the soil and water availability much of the land area will not support Cocos at present. The continued use of the island by man promises to significantly alter the natural ecosystems.

Among the introduced plants of the village the Erythrina trees mentioned by Rougier (1914) are still alive. Common around the village are Hibiscus rosa-sinensis and H. schizopetalus, Lycopersicon esculentum and Carica papaya although these latter do not seem to thrive. Mr. Cook showed me a small pit along the north road which was fenced with metal roofing and about 1 m. deep. In tin containers the native Gilbertese were growing Cryptosperma chamissioniana. The plants were not vigorous and many were lost to the ravages of the land crabs which are numerous. The taro is grown for the Gilbertese women who prefer this diet during pregnancy. Growing nearby was a small shrub of Ficus tinctoria about 2 m. high which was cultivated for its fruits. Later it was also seen growing near some houses in the village.

The vegetation

The natural vegetation of Christmas Island is characterized by xeric and semi-xeric Pacific strand species such as Portulaca lutea, Heliotropium anomalum, Scaevola and Tournefortia. (Christophersen, 1927). These herbs and shrubs along with Sida, Suriana, Hedyotis and Lepturus form distinct associations which at one time covered the atoll, the largest in land area found in the world. The island appears to have been created from a group of smaller islets which were united by storm and wave deposited debris and, possibly, uplift. (Rougier, 1914). These old islets forms the upland areas of the island which are covered with a Scaevola-Tournefortia association mixed with open areas of Sida and Lepturus. A banded type of association arrangement is found around the shores of the inner lagoon and lagoon flats where a Suriana-Hedyotis association is common above the periodically flooded areas. An undergrowth of Sida, Lepturus and Portulaca is common in open areas between the edge of the lagoon and the Scaevola scrub. Sesuvium forms associations with Eragrostis whitneyi and Heliotropium at the lagoon edge or on the raised islets of the lagoon area. Often Sesuvium forms pure stands in these areas. In 1965 a Cuscuta sp. was discovered on one islet in the heavily dissected area of the lagoon in the middle portion of the island. A number of islets were inspected but no other locale was found for this undetermined species. Lepidium bidentatum occurs in dry open areas near the lagoon on the SW end of the island.

The three islets of the Christmas atoll are interesting in that some but not all of the species found on the larger island are represented in a relatively small area. Cook Island is sparsely covered, in some places just at the periphery, with the Scaevola-Tournefortia association. Heliotropium and Portulaca are found on the dry open portions with Lepturus and Sida forming a relatively thick cover on the S end of the island. Cassytha is found on the Boerhavia, Scaevola, Portulaca and Sida. The soils are made up of sand and coral rubble. The two smaller islets of Motu Upua and Motu Tabu are sand islets with Scaevola - Tournefortia scrub. On Motu Tabu a Pisonia tree to 5 m. is found in the center of the island and several small Hedyotis shrubs were found on the E Shore just above the high tide line on the sand and gravel beach. Seedlings of Tournefortia, Scaevola and Eragrostis whitneyi were found in pioneer areas of newly deposited sand on the E side of Motu Tabu and Motu Upua. Tribulus cistoides and Boerhavia repens are found on all three islets sometimes forming thick mats of overlapping stems. These species often form a considerable litter.

The S area of the island was surveyed in 1965. Of special interest was the ground zero area of the 1957 bomb test site and adjacent areas to the north of the site. The vegetation in the S area consists at present of Lepturus - Sida stands with Portulaca and Boerhavia. Tribulus is found in patches. This vegetation type approximates that which was present before the tests. The Scaevola - Tournefortia cover on the S part was almost completely eliminated. In 1965 the dead remains of large Tournefortia trees were to be seen. Scaevola scrub appeared to be recovering by sprouting from the base. Some of these were 1.5 - 2.5 m. high. New plants probably from seedling were evident along the south shore. Nesting bluefaced boobies and sooty terns were present in these open areas in large numbers.

Cocos plantations

The planting of Cocos began with the European discovery of the island. A few trees were found by Cook's party and other nuts were planted. The extent of the Cocos areas was increased during the development of the island by Father Rougier who planted large areas on the NW, N, NE and SW sides of the islands comprising the plantations found along the slopes of the high areas. Copra production continues at present. The extension of the Cocos groves is being carried out at the rate of 1200 acres per year. This operation is under the direction of Mr. Cook the District Commissioner for the Line Islands. Planting is at present centered on the NW and N sides of the island along the highway built by the military during the bomb test era. The plantations have a cover of Lepturus and Portulaca with Boerhavia and Sida at the fringes of the open areas. Large acreages have been cleared of Scaevola - Tournefortia scrub. Tribulus thrives in some of the open areas where the newly sprouting coconuts are planted. Mr. Cook is expanding the facilities in the village of London for sprouting coconuts before planting. He has found from experience that better success is achieved by using this method. During 1964 a dry period browned many of the fronds on the mature trees and production was hampered. The groves on the SW side were particularly dry and this continued into 1965.

The larger number of introduced species are found in the village at London and on the N side in the heavily disrupted area around the airport where facilities existed for the support of several thousand military personnel. Pluchea odorata and P. indica are found in this area along with the sterile but aggressive hybrid between these two species. The hybrid has become a common weed in the Hawaiian Islands and is also found on Palmyra Island also in the Line Group. This hybrid and one parent, P. odorata are found along the roads and old barracks. P. odorata is common at the open edges of the Cocos groves adjacent to the heavily used areas. On the SW side at Paris Pluchea odorata is forming thickets along the edges of the groves and appears to be spreading into open areas of Lepturus and Boerhavia. There is the distinct possibility that this species could compete in some areas with the native vegetation particularly the Scaevola-Tournefortia scrub. It is also found on Motu Upua on the interior of the island but does not appear to be spreading in this location.

The plant association found at the edge of the numerous lagoons and isolated islets in the lagoon at Christmas are fascinating areas for the study of succession and zonation. Of particular interest are former reef mud flats and hardpans upon which one finds a mixed association of Scaevola, Hedyotis and Suriana with Portulaca lutea and Lepturus forming a ground cover. Scattered mats or individual plants of Sesuvium are found on the isolated islets or on the edges of tidal runs along with Eragrostis whitneyi. In such areas the roots are well watered with saline water. The substrate of such areas vary from coral gravel and sand deposited by the flow of water across the lagoon to reef mud which upon drying quickly forms a hardpan layer.

Boerhavia is a common component of the flora of Christmas island from the sand beaches to the upper edges of the lagoon. It is found in every association except the extremely saline ones. Optimal growth is found on sandy soils in open areas. Boerhavia seems to colonize cleared land which is planted to Cocos and remains though less conspicuous after the groves mature.

The Pisonia tree on Motu Tabu bore sticky fruits. However, only one other Pisonia tree was found on the island near the wells on the NW side. According to Mr. Cook this tree had been planted near the well house. A survey for Pisonia in those Cocos groves planted along the well watered slopes of the groves on the north side revealed no young trees. It may be supposed that the irregular rainfall of the island contributes to the failure of the spread of this forest tree. Large Pisonia trees are found on Palmyra and Washington Islands to the north and a few, on Malden to the south within the Line Group.

A number of introduced herbs and grasses are common around London and the roads which stretch north and east. Cenchrus echinatus, Eleusine indica, Eragrostis tenella and Digitaria pacifica are common in such disturbed areas. Other atoll weeds such as Euphorbia hirta, and Vernonia cinerea are common.

The lack of abundantly sprouting coconuts in established groves attests to the irregular rainfall of the region. The amount of rainfall appears to be enough to support Cocos plantations under cultivation but extensions of the present Cocos plantations currently underway may tend to exhaust the lense of fresh water especially during the frequent dry periods. The present extensions of the plantations on Christmas Island are being carried forward with a view to expanding the plantations in order to relieve the population pressures on the Gilbert Islands by transferral of colonists to Christmas Island. Previous attempts to colonize Hull, Sydney and Gardner Islands to the west (1937-1963) resulted in failure. Any such attempts to increase the population of Christmas Island must be made after a thorough ecological study of the island has been made. In line with this Mr. Richard N. Jenkin, Land Resources Division, Directorate of Overseas Surveys, has been sent during 1965 to do extensive surveys of Christmas Island.

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Christmas Island - A Preliminary List of Plants Collected by C.R. Long
June 14 - 18, 1964 ATF Trip.

June 14, 1964

Christmas Island, Cook Island

1. Lepturus repens (Forst.) R.Br.
2. Cassytha filiformis L.
3. Messerschmidtia argentea (L.f.) Johnston
4. Tribulus cistoides L.
5. Boerhaavia diffusa L.
6. Heliotropium anomalum H. and A.
7. Cocos nucifera L. (observed)

June 16, 1964

Christmas Island, Main Island

1. Messerschmidtia argentea (L.f.) Johnston
2. Eragrostis amabilis (L.) W. and A.
3. Scaevola taccada
4. Lepturus repens (Forst.) R.Br.
5. Sida Fallax Walp.
6. Portulaca lutea Sol.
7. Cocos nucifera L. (observed)
8. Digitaria pacifica Stapf.
9. Fimbristylis atollensis St. John
10. Heliotropium anomalum H. and A.
11. Suriana maritima L.
12. Pluchea odorata (L.) Cass.
13. Sesuvium portulacastrum L.
14. Boerhaavia diffusa L.

June 15, 18, 1964

Christmas Island, Motu Upua

1. Lepturus repens (Forst.) R.Br.
2. Heliotropium anomalum H. and A.
3. Sesuvium portulacastrum L.
4. Sida fallax Walp.
5. Portulaca lutea Sol.
6. Messerschmidtia argentea (L.f.) Johnston
7. Eragrostis whitneyi Fosberg
8. Cassytha filiformis L.
9. Suriana maritima L.
10. Pisonia grandis R. Br.

June 18, 1964

Christmas Island, Motu Tabu

- | | |
|---|--------------------------------------|
| 1. <u>Kadua romanzoffiensis</u> C. and S. | 5. <u>Sida fallax</u> Walp. |
| 2. <u>Lepturus repens</u> (Forst.) R.Br. | 6. <u>Portulaca lutea</u> Sol. |
| 3. <u>Heliotropium anomalum</u> H. and A. | 7. <u>Cassytha filiformis</u> L. |
| 4. <u>Suriana maritima</u> L. | 8. <u>Sesuvium portulacastrum</u> L. |
| | 9. <u>Tribulus cistoides</u> L. |

Christmas Island - June 14, 1964

Cook Island - Around the periphery of the island is a often broken and discontinuous stand of Messerschmidtia and Scaevola. On the southwest part of the island the Messerschmidtia - Scaevola association is found on the interior of the island as well as along the rim. The Scaevola is most often found in rocky areas along the beach. Both Lepturus and Digitaria are found on the sandy beaches and are particularly common on the west beach. The Lepturus forms many stolons although the clumps are never as large as those observed on some of the other islands. Much of the vegetation on Cook Island and especially the Scaevola and Heliotropium are covered with Cassytha. In some of the drier areas on the inner part of the island this parasite seems to have a definite effect on the extent and condition of the Heliotropium dominant vegetation. The Cassytha is found also on Messerschmidtia shrubs which are wholly or partially killed by the mass of this parasitic vine. The Heliotropium on the inner part of the island is more often found with upright stems than that which grows along the shore. Portulaca was found often in shaded positions under shrubs and these plants were in flower. In contrast to the healthy appearance of these were those plants growing on the arid inner portions with the Heliotropium. Tribulus is found in the southern portion of the island forming thick mats in some areas. I assisted in the banding of sooty terns during the evening.

June 15, 1964 - We returned to the U.S.S. Takelma at about 10:45 am. We finished pressing the Cook Island collections and changed the cardboards of the other presses. The drying has not been satisfactory for many of the collections made on Palmyra and Washington Islands. The engine room is hot while the ship is underway but even then the humidity is too high for good success in plant drying. The frequent stops made by the ship added to the uneven quality of the drying. We leave the ship for Motu Upou at about 2:30 pm. In early evening I assist in banding the Christmas Island Shearwaters found on this Motu. The sooty shearwaters are found on open gravel areas on Motu Tabu. Stands of Lepturus - Sida and Lepturus - Scaevola associations are found on Motu Tabu. Red-footed boobies are found nesting in the Messerschmidtia. The Christmas Island shearwaters are found under dense tangles of Cassytha over Heliotropium in the more open areas of the island. These birds and the sooty shearwaters are also found under the cover of the heavy Scaevola - Messerschmidtia scrub into the inner tangle of which they flee when one attempts to grab them for banding. The Phoenix Island shearwater is found in depressions under the Cassytha - covered Heliotropium. The natural activities of these birds is responsible for hollowed out depressions beneath the plant cover. The wedgetailed shearwater is found in areas where the soil is friable and usually where the soil is somewhat deep. Grass covered areas with heavy fibrous root penetration and the concomitantly better soils are favored by this burrow building species. The heavy organic material which is a part of grass covered soil types makes burrowing possible. The nesting Hawaiian noddies on Cook Island built nests of Messerschmidtia inflorescences and Turbinaria sp. - the east shore of Cook Island being littered with this common alga. Around the Messerschmidtia on Motu Upou is a hard crust of guano from the nesting birds. This layer is often one-half to three-quarters of an inch thick. The Suriana shrub is found growing to over four feet on the outer portions of the island. The Portulaca found on the north side of this island is appressed to the soil surface (wind is from the north) while on the south shore the plants of this species are upright and have thick succulent stems. The plants of both areas are in bloom. A Sesuvium - Lepturus stand is found on the outer edges of coral sand around the periphery of the island but this is far from

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forming a continuous band. The Sesuvium is found on the southeast end alone. The Cassytha is found on Heliotropium and on Suriana but is not as conspicuous on Motu Upou as on Cook island nor does the parasitized vegetation seem in as bad a condition. The Scaevola on Motu Upou seems to have smaller flowers than that observed previously. I think that this particular group of plants is quite distinct from the ones observed and collected on Palmyra. Perhaps the water availability is a key factor. The vegetation resembles the south end of Cook Island although there is less Tribulus and Boerhaavia. Boerhaavia does occur on Motu Upou in dense patches on the inner parts of the island. In the Heliotropium - Lepturus association on the west side of Motu Upou the action of the nesting shearwaters has had the tendency to mound the soil with the plants on top of the mound.

June 16, 1964 - L. Huber, F. Sibley and I were forded to the peninsula of Christmas Island which was northeast of Motu Upou. We followed the road east through the Cocos groves and past the airfield to the northeast point. We then continued south along the shore road along the Bay of Wrecks and along the southeast shore to the point where the shore line turns south. I fell behind the others at the northeast point while collecting - later overtaking them and passing as I continued southeast along the road. It was a hot day and the plants wilted fast. In order that I could botanize on the return trip I left at dusk and rode along the Bay of Wrecks after dark sleeping at the roadside from 8 pm. until 3:30 when a shower awakened me. I waited for first light and retraced the previous days route collecting along the way. The long southeast peninsula is interesting and I hope that we will have the opportunity to do a more thorough job in that area. The large land area of Christmas Island makes for a variety of plant associations which were observed along the southeast shore. On the rocky, uplifted sites along the road occur Scaevola - Lepturus and/or Heliotropium associations. The latter species usually occurs in sandy soils where the beach has "blown out" or in wind blown sand pockets in the coral rubble. Along the shore occur stunted or half dead plants of Messerschmidtia. The prevailing wind is from the east and this would seem to be a factor. In the depressed inner part of the island where the wind does not have full desiccating effect the Messerschmidtia grows quite high and has much less dead wood per tree. Large parts of the inner portion of the island are filled with Scaevola, open areas of solid Lepturus, and Lepturus - Sida. The low "lakes" or inner lagoons have rings of vegetation with Sesuvium on the inner side and forming a solid mat on the floor of the depression. On the higher, dry sides one finds seedlings of Portulaca, and then a bare area with a few Lepturus seedlings followed by more solid clumps further back from the edge of the Sesuvium mat. Several score of yards from the edge the Lepturus and Scaevola are mixed and then one finds a solid Scaevola stand. The following associations were observed:

1. Scaevola - Lepturus - Messerschmidtia
2. Messerschmidtia - Heliotropium - Portulaca
3. Lepturus - Sida - Scaevola
4. Lepturus - Portulaca
5. Digitaria - Fimbristylis (Digitaria covering large areas to the east of the road east and south of the airfield.)
6. Sesuvium - Messerschmidtia - Lepturus
7. Lepturus - Suriana - Messerschmidtia - Portulaca
8. Suriana - Heliotropium

The controls on the spread of any one species or species association are many: wind protection or not; soil base - from fine coral sand to coarse

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coral rubble, or, hardpan soils; standing water - salt or fresh; salt spray; enclosed lakes or "lagoonlets"; rainfall; insolation and reradiation of light energy. The insolation for Christmas Island is very high and the heat accumulation over the large land area is great despite the prevailing winds. There were showers every late afternoon and early evening of our stay on the island. On the northeast part of the island where the Cocos plantations are being extended many bare areas are being drained. Under the Cocos trees one finds Lepturus and where the shade is not dense Pluchea. This latter genus is also found around the old barracks and buildings in the general area. The Pluchea grows to a height of 10 feet. The Suriana - Messerschmidtia stands which are found most commonly around the shores of the lagoon have abundant litter. In some areas one finds no clearly defined associations with most of the herbaceous species being present. In one area the following species were observed growing in the same area: Lepturus, Heliotropium, Cassytha, mixing with one or all of: Portulaca, Sida, Boerhaavia, Scaevola. Cocos forms a heavy litter. A layer of blue green algae was observed about one-quarter of an inch below the soil surface. On the bare areas surrounding the lagoon - composed of surfaces just an inch or two above the high tide waters - I think that Sesuvium and Lepturus are first colonists with Suriana following. Digitaria is commonly found on the northeast shore with Heliotropium and Scaevola. Past the Site Y cutoff Lepturus is found in a solid stand. The Scaevola is found in protected sites. If not, the plants are wind damaged and very compact in growth. On the sand hills across from the site M on the east side are Lepturus and Sida (in bloom). On the west side of the road are Scaevola and Messerschmidtia. Scattered Messerschmidtia are found along the shore bluff. About one-quarter mile past site M on the left one finds the Suriana - Heliotropium association. On the rise toward the beach Scaevola is found. Near the twin antennae installation are large areas covered with Lepturus - Sida with Messerschmidtia along the outer shore, above the beach.

June 17, 1964 - Motu Upou - Information for vegetation mapping was secured. Four permanent markers were placed on this Motu:

1. fifty paces southwest along old water pipe line from the ne. shore;
2. thirty-seven paces due south of the mid point on the northeast shore;
3. as above but ninety paces further south;
4. forty paces south of the northeast shore toward the east point.

All of these markers are at least 41 in. above the soil surface and were sprayed green in color. The following associations are represented: 1. Lepturus - Heliotropium; 2. Heliotropium - Cassytha - Boerhaavia; 3. Heliotropium - Portulaca - Lepturus; and, 4. Messerschmidtia - Suriana - Heliotropium - Cassytha.

June 18, 1964 - From 6 am. to 9am. I firmed the stakes placed the previous day and took a soil profile sample in the Heliotropium - Cassytha - Lepturus stand near the west end of the island just in back of the camp area. We then prepared our gear for Motu Tabu which is almost due south of Motu Upou. After setting up a tentless camp we set out to work over the island. The soils on Motu Tabu are based on sand - the top layers are whitish, the underlayer with moisture drawn up from the sea level lens beneath the island. This layer is light brown in color. The Phoenix Island petrels often make a semicircular depression at the base of a Lepturus clump. The Cassytha - Heliotrope association forms a nesting area for many shearwaters. L. Huber informs me that the wedgetailed shearwaters may burrow in bare sand if enough depth is present thus vegetation is not needed for the formation of certain soil types which favor burrowing. Thus an open sandy islet will provide an area where burrows can be made - the vegetationless Leewards were cited as examples. I saw one

Phoenix Island Petrel egg in the open under a Suriana bush. This type of habitat for nesting seems to be an exception. On Motu Tabu the Christmas Island shearwaters nest under vegetation without making burrows. Nests of the Hawaiian noddy were observed constructed of Messerschmidtia inflorescences and Turbinaria while those of the common noddy were made from small Messerschmidtia and other types of twigs.

Most of the plant species were in bloom during our visit: Lepturus, Boerhaavia, Sesuvium, Sida, Portulaca, Heliotropium, Pisonia, Tribulus, Cassytha and Suriana. The latter genus has five yellow petals (probably fading to white after exposure to the sun). On the west end of the island the Lepturus-Tribulus - Boerhaavia association forms a conspicuous patch. On the east side of the island Messerschmidtia logs are burrowed heavily by the Christmas Island shearwaters. At the southwest end of the islet were two Scaevola bushes and several young plants. Solid Lepturus - Boerhaavia stands occur among the Messerschmidtia bushes. The small Pisonia are relatively leafless - soil surface beneath is bare of other vegetation. Wedgetailed shearwaters are found in the fine sandy area on the west end of the island. Sketch maps of Cook Island, Motu Tabu and Motu Upou were taken from: Series X782, Christmas Island, Edition 2-GSGS, Pub. by D. Survey, War Office and Air Ministry, 1957, Printed by Army Map Service, Corps of Engineers, 4-59, 102674. Eggs and young of Hawaiian noddies were present in various stages of development in the leaf nests heavily matted with guano. The noddies and terns perch in the upper dead limbs of the Messerschmidtia - green sprouts appear below. Stems of Tribulus up to two ft. in length. Christmas Island shearwaters with burrows at the edge of the Lepturus stand. Red-tailed tropicbirds were nesting under the Messerschmidtia scrub. On the northeast side of the island one plant of Hedyotis (Kadua) was found with large white to dark bluish berries. This plant was observed growing in the bare soil only several feet from the high tide mark in an environment where one might expect Suriana. This was the only plant seen on Christmas Island. The following species or species associations were observed on Motu Tabu:

1. Heliotropium - Suriana - Messerschmidtia (few)
2. Heliotropium - Suriana - Lepturus - Cassytha
3. Suriana - Messerschmidtia
4. Tribulus - Heliotropium - Lepturus
5. Portulaca - Heliotropium - Lepturus
6. Suriana - Lepturus
7. Pisonia

Two permanent markers were placed on Motu Tabu:

1. twenty paces from the mid-northeast shore, steel pole is 47 in. above the surface and painted green;
2. on the northwest point in the Lepturus - Heliotropium stand approx. fifty paces from the post sunk into the shore and south by southwest of these.

June 19, 1964 - We were up at 6:30 am. return to the U.S.S. Takelma by 11 am. after decamping from Motu Upou. We repack and return to Cook Island. Much of the Scaevola is parasitized by the Cassytha. This may act as a deterrent to the spread of this species on Cook Island. The depressed coral rubble area in the northwest part of the island has no well defined associations but rather a somewhat random dispersal of species. More nesting sooty terns are present on the island since our last visit. Eggs are placed in both completely exposed and shaded positions but the latter seems more common. Sooty terns sometimes use twigs and leaves of Messerschmidtia in thier nest.

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The Cassytha forms a dense mat over Tribulus and Messerschmidtia in some parts of Cook Island. The nest density of the Hawaiian noddy in the dead or dying Messerschmidtia is very high. These birds must contribute to the denudation of these shrubs and small trees by using the leaves and inflorescences as nesting material. We observed about ten masked boobies and one grey-backed tern while enroute to Cook Island. On the stony coral area on the north side of Cook Island one finds large circular stands of Tribulus and Boerhaavia which have become established at the base of Messerschmidtia shrubs. There are two brackish potholes on the southwest end. Scaevola forms a ring around these areas. The northwest of the island is drier with the ring of Messerschmidtia - Scaevola broken up into a few clumps scattered along the shore.

June 20, 1964 - We banded sooty terns from 3 am. until 6:15 am. (480) and Hawaiian noddy nestlings (100).

Two permanent markers were placed on Cook Island:

1. On the southwest end in Heliotropium - Portulaca - Lepturus stand due southeast of the tower on the west point; and
2. On the northeast end in Heliotropium - Portulaca stand sse of the tower on the ne. end. Both of these permanent markers are at least forty inches above the soil surface and provide excellent photographic coverage of the major features of the island.

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A List of Slides Taken by C.R. Long - Christmas Island, June 14, 16, 17, 1964.

June 14, 1964 (July, in red)

2. Cook Island, southwest beach vegetation, young Messerschmidtia, Lepturus.
3. Mid-south section of Cook Island, Heliotropium and Cassytha on flat inner sand area.
4. Heliotropium, Cassytha flat on inside portion of Cook Island, Messerschmidtia grove.
5. Nw. shore with sparse Heliotropium and Messerschmidtia.
6. Nw. side of Cook Island, Messerschmidtia groves in rubble, Heliotropium in sand.
7. Looking toward sw. shore, island rim of Messerschmidtia.
8. Nw. portion of island, Boerhaavia, Heliotropium, Cassytha, Lepturus.
9. (as in 8.).
10. Nw. part of Cook Island, Sida, Heliotropium, Cassytha.
11. Close-up of Cassytha covered Heliotropium.
12. North portion, large Heliotropium growing in sand pocket of coral rubble.
13. Digitaria growing in sand pocket of coral rubble.
14. Boerhaavia (red stemmed and purple flowered) growing under Messerschmidtia in the north part of the island.
15. Messerschmidtia growing in coral rubble, nesting noddies.
16. Suriana - Heliotropium association on Motu Upou, looking east.
17. Heliotropium, Eragrostis, Portulaca along the se. shore of Motu Upou - washed up Cocos nut.
18. Suriana - Messerschmidtia association along the north side of Motu Upou, with Lepturus and Suriana seedlings in the beach sand.
19. (as in 18.)
20. Close-up of Portulaca sp. on Motu Upou.
21. Sesuvium - Portulaca association on e. shore of Motu Upou.
22. Open Heliotropium - Suriana association on east shore Motu Upou.
23. As in 22. but looking w. toward the Cocos plantings.
24. Scaevola, Boerhaavia mat, inner part of the island.
25. Looking e., n. shore of Motu Upou, Suriana along beach.
26. N. side of Motu Upou, Lepturus - Heliotropium.
27. Guano deposits along the bare soil area on the se. shore.
28. Red-footed booby mother and nestling in stick nest - Messerschmidtia.
29. East point of Motu Upou looking east, low tide, note sand spit covered with Messerschmidtia.
30. Boerhaavia, Portulaca, Tribulus, Heliotropium - s. end of Motu Upou.
31. Heliotropium, Scaevola, Lepturus, Messerschmidtia - south side shore vegetation of Motu Upou.
32. Along road, east side of Christmas Island, looking west - Messerschmidtia, low Sida and Lepturus along the roadside.
33. (as in 32.).
34. Sida, Lepturus, Heliotropium, young Scaevola on the east side in formerly disrupted area.
35. Lepturus, Sida, Heliotropium, Cassytha in sandy area on the east side of Christmas Island, east of the road toward the beach.
36. Ne. side of the island midway along the Bay of Wrecks, looking west toward the lagoon area - Sesuvium mats, Messerschmidtia at edge of depressed lagoon, Lepturus clumps in foreground in bare soil underlain by hardpan.
37. As in 36. but closer to the Sesuvium mat which is very thick and lush in growth.

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June 16, 1964 (August, in black)

1. Portulaca lutea Sol. and Lepturus repens (Forst.) R.Br. along road-side, east side of Christmas Island.
2. Beach strand vegetation along the east side: Scaevola, Boerhaavia, Heliotropium and Lepturus.
3. (as in 2.).
4. Vegetation on the highly disturbed roadside - Lepturus.
5. Sida, Lepturus, Boerhaavia, Messerschmidtia on the east side of the island.
6. Looking toward the west lagoon from the road, Scaevola.
7. Scaevola, Lepturus, Heliotropium on sand on east side; note sand hillocks above the beach.
8. Sida, Lepturus - looking w. toward the lagoon.
9. Suriana, Lepturus, Messerschmidtia, behind the high rock beach, east side.
10. Suriana, Sida, Lepturus looking toward the inner lagoon.
11. Sida, Lepturus, Messerschmidtia on lagoon side of the east road.
12. Roadside - Cassytha, Messerschmidtia.
13. Beach side of the east road - Lepturus and Messerschmidtia.
14. Sunset, rainclouds - heading northwest along road in the early evening.
15. Lepturus, Messerschmidtia - clearings for new Cocos plantations.
16. Lepturus, Scaevola, Cocos, Pluchea - ne. side of island area west of air-field.
17. Lepturus and Scaevola, Cocos plantation in back.
18. Cocos grove, military rubble on the nne side of the island.
19. Cocos plantation, Lepturus clumps scattered beneath.
20. Open area - nne side of island.
21. Open area - nne side in drained area.
22. Cocos, Suriana along east shore of lagoon.
23. Suriana, Messerschmidtia east side of lagoon near tidal flats.
24. As in 23. - taken at low tide.
25. Sesuvium, Lepturus on raised sand flat, east shore of lagoon looking toward Motu Upou.
26. East end, Motu Tabu - Suriana, Messerschmidtia.
27. Motu Tabu, with Suriana, Cassytha, Messerschmidtia.
28. Pisonia - small tree to twenty feet, many nesting noddies.
29. Messerschmidtia and Pisonia on inner part of Motu Tabu.
30. Pisonia, Lepturus (lush), and Suriana.
31. Heliotropium and Lepturus on the sw. end of Motu Tabu.
32. South side Motu Tabu - Messerschmidtia, Heliotropium, Lepturus, Suriana.
33. Sesuvium, Lepturus, Messerschmidtia, Sida - looking east.
34. Messerschmidtia, Lepturus on Motu Tabu.
35. Sesuvium - close-up of the white flowered variety.
36. Lepturus, Heliotropium, Tribulus in open area on sw. side of Motu Tabu.
37. Lepturus showing vigorous growth here and Messerschmidtia with nesting noddies.
38. Suriana, Scaevola and Lepturus on the se. side of Motu Tabu.

Insert
June 17, 1964

C.R. Long
1964

*Summary of June - July
Botanical Fieldwork*

Christmas

June 10, 1964

Soil samples, bog cores and photographs taken. Collection No.

1845a - 1845x.

June 11, 1964

Collected in west area (bogs), across fresh water lagoon to the east end of the island. Photographs, bog core samples and soil samples taken. Collection No. 1859 - 1865.

June 12, 1964

Soil samples and photographs taken. Observations on north shore for vegetative map of the island.

Christmas Island

June 14, 1964

Cook Island Collection No. 1845 - 1858. Assisted in the banding of sooty terns.

June 15, 1964

Cook Island

Motu Upua - Collection No. 1884 - 1895.

June 16, 1964

Observations and collection made along the southeast coast of the main island, Christmas Island. Photographs were made. Collection No. 1896 - 1909.

June 17, 1964

Motu Upua - Permanent markers were placed and photographs taken. Assisted in banding Christmas Island Shearwaters.

June 18, 1964

Motu Tabu - Vegetation transects, soil collections and plant collections made. Photographs taken. Collection No. 1910 - 1919.

Motu Upua - Permanent markers adjusted and photographs taken.

C.R. Long
1964

June 19, 1964

Cook Island Vegetative Transects made.

June 20, 1964

Assisted in banding sooty terns and noddys.

Malden Island

June 22, 1964

Collections were made in west, mideast, north and northwest areas of the island. Collection No. 1920 - 1935. Photographs and soil samples taken.

June 23, 1964

Collections were made in the southwest, south, east, and northeast parts of the island from lagoon edge to beach. Collection No. 1936 - 1938,

C.R.Long.

June 24, 1964

Photographs were taken. Permanent markers placed. Collection No. 1939 - 1942, C. R. Long.

Starbuck Island

June 25, 1964

Walked east and north during evening.

June 26, 1964

Collected along the north shore heading east then south. Vegetation transects and soil samples were taken. Collected to east end of the island. Collection No. 1936 - 1948.

June 27, 1964

Vegetation transects and soil samples were taken. Permanent markers placed.

C.R. Long
1964

Soil Samples - June-July 1964 Christmas

Depth of hole: 63.5 in. Each 2 inch portion represents approximately (3.96) 4 in. Water filled the hole to within 22 in. of the surface.

Associated with Scirpus are Cyperus and Polypodium sp., the latter forming small hummocks above the surface, the former found rooted in the surface material.

XVII - crust sample from bare surface area near Site No. 1.

Site II collections 1 - 17

Scirpus bog approx. 100 yards from fresh water lagoon north side of the canal.

Samples No. 1-No. 17 (1-17 represent 2 inch portions taken from the sampler).

Depth of hole: 47 in. water filled the hole to within 5 in. of surface.

Site III

Depth of Scirpus peat in excess of 72 in. No samples taken.

June 14, 1964

Cook Island (Christmas Island)

(3) L236-L238

Coral sand, light brown color.

L236- 1 top 1 inch-3in. layer. Plant species: Boerhaavia, Cassytha,

L237- 2 1 in. to 2 in. deep } Heliotropium, and Lepturus.

L238- 3 1 in. to 2 in. deep } → Same description of No. 1

June 15, 1964

Motu Upua (Christmas Island)

(4) L239-L242

L239- 1 2 in. to 3 in., lighter color.

L240- 2 upper 1/4 in. of upper hard surface soil- base area, Heliotropium

L241- 3 1/4 in. to 2 in. deep - brown color soil under hard crust.

L242- 4 open areas near salt bush.

June 17, 1964

Main Island - Christmas Island

(3) L243-L245

L243- 1 Cocos plantation 1 in. to 2 in.

L244- 2 Lepturus top 1/2 in. pebbles on top.

L245- 3 Lepturus stand 1 in. to 2 in.

June 18, 1964

Motu Upua (Christmas Island)

(4) L246-L249

L246- 1 Heliotropium, Lepturus - 6 in. - 9 in., many roots- light brown color - burrows of Phoenix Petrels and wedgetailed shearwaters

L247- 2 Heliotropium, Lepturus, light brown soil - roots to 9 in. - top white gravel - 9 in. to 12 in. burrows of Phoenix petrel and wedgetail shearwaters.

L248- 3 Heliotropium, Lepturus - 3 in. - 6 in. root area - burrow Phoenix petrels and wedgetail shearwaters.

L249- 4 Heliotropium, Lepturus - top 0 - 3 in.

1964

- June 18, 1964 Motu Tabu
 (5) L 178-L182
 L178 - 1 1-2 in., under Pisonia
 L179 - 2 Lepturus, Boerhaavia, Portulaca, Heavily mounded area, fine sand area.
 L180 - 3 open area, salt bush, 1-2 inches.
 L181 - 4 Messerschmidtia, 1-2 in.
 L182 - 5 Bottom of old burrow under Lepturus, in Lepturus, Boerhaavia, Portulaca stand. Fine sand area, approximately 10 feet depression, wet 1/2 inch down.
- June 22, 1964 Malden Island Lagoon
 (1) L183
 L183 salt crust
- June 23, 1964 Malden Island
 (5) L184-L188
 L184 - I and L185 - II Soils forming among raised coral heads - Surfaces bare but Sesuvium forms a peripheral ring about the lagoon. Top 1/2 inch whitish with salts then dark red layer extends to several feet in depth. Between these two layers is a noticeable layer of blue-green algae?
 L184 - I bare soil in old coral rock, Sesuvium, top 1/2 in..
 L185 - II top 1-2 in., bare soil in old coral rock, Sesuvium.
 L186 - III top 1/2 in. Sida, Digitaria, Portulaca. North side of island Boerhaavia, Tribulus.
 L187 - IV top 1/2 to 2 in. Sida, Digitaria, Portulaca, Boerhaavia north side of island.
 L188 - V bare area among Sesuvium, grasses, on flat rock, 1/2 to 2 in., top layer white with much salt.
- June 26, 1964 Starbuck Island
 (5) L189-L193
 L189 - I Portulaca, Sesuvium, Eragrostis - shells on top 1/2 - 2 1/2 in.
 L190 - II 1/2 - 2 in. Lepturus, Sida
 L191 - III guano soil Lepturus thick, some Sida, 0-1/2 in.
 L192 - IV guano soil Lepturus thick, Sida, 1/2 - 2 1/2 in.
 L193 - V Digitaria, Sida, Tribulus 1/2-2 in. coarse gravel on top
- June 27, 1964 Starbuck Island
 (4) L194-L197
 L194 - VI at Post No. 1 1/2 - 2 1/2 in.
 L195 - VII midway to post No. 2 on rim 1/2-2 1/2 in.
 L196 - VIII at post No. 2 1/2-2 1/2 in.
 L197 - IX Digitaria stand west end 1/2-2 1/2 in.
- July 4, 1964 Tuituila, American Samoa
 (1) L198
 L198 Forest 800 feet 1/2-2 in.